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MEASUREMENTS OF THE LOW-FREQUENCY WIND-GENERATED AMBIENT NOISE --ETC(U)
OCT 81 R W BANNISTER, R N DENHAM, K M GUTHRIE
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Measurements of the Low-Frequency Wind-Generated Ambient Noise in the Deep Ocean

A Paper Presented at the 101st Meeting of the Acoustical Society of America, 21 May 1981, Ottawa, Canada

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Preface

This document was prepared under the sponsorship of the Undersea Warfare Technology Office, Naval Sea Systems Command under NUSC Project No. A65005, *Ambient Noise Characteristics*; NAVSEA Program Manager, F. J. Romano, and NUSC Principal Investigator, D. G. Browning.

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Southern Hemisphere Noise
Wind-Generated Noise

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This document presents the oral and visual presentation entitled "Measurements of the Low-Frequency Wind-Generated Ambient Noise in the Deep Ocean," presented at the 101st Meeting of the Acoustical Society of America, 21 May 1981, in Ottawa, Ontario, Canada.

Southern Hemisphere oceans provide unique conditions for the measurements of low-frequency wind-generated ambient noise due to their relatively low shipping densities. Results (10-500 Hz) for a single location in the

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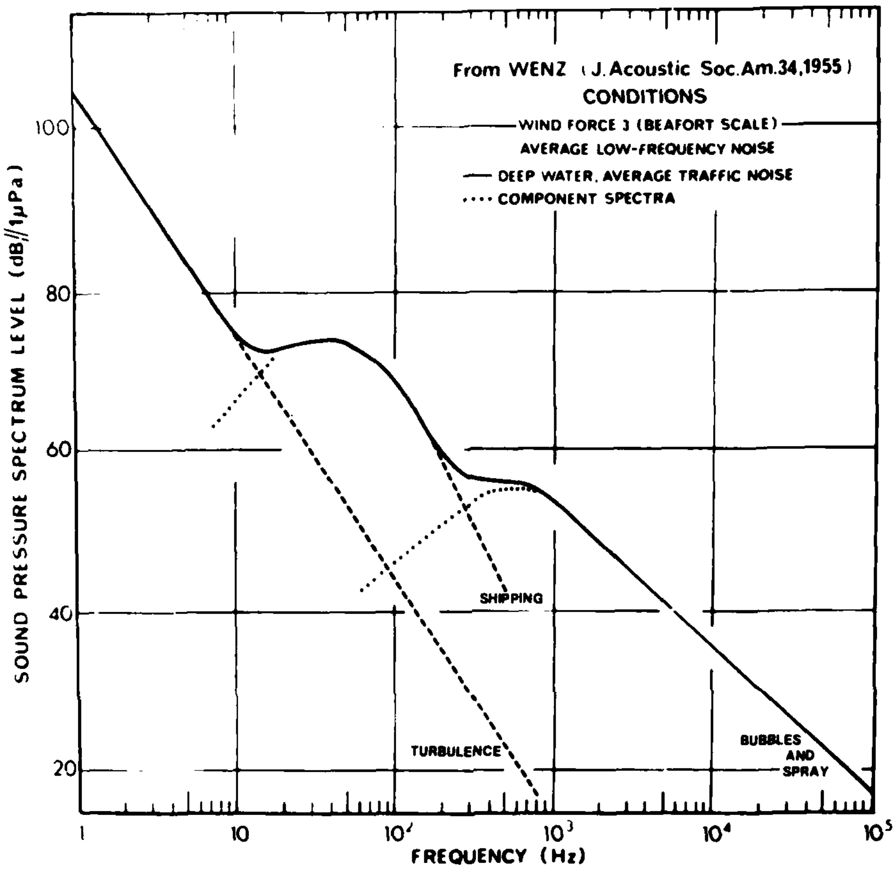
20. (Continued)

South Fiji Basin (R. W. Bannister, J. Acoust. Soc. Am. 60(S1), S20(A), 1976) supported the two principal noise generation mechanisms that have been suggested: turbulence, bubbles and spray. For a given local wind speed, higher noise levels were observed than have been reported for the North Atlantic Ocean. This paper is an analysis of wind-generated noise data from additional sites throughout the Tasman Sea-Fiji Basin region. Variation in measured level is compared to wind speed, sea state, and propagation conditions. It appears that local wind speed is not an absolute indicator of wind generated ambient noise level.

Measurements of Low-Frequency Wind-Generated Ambient Noise in the Deep Ocean

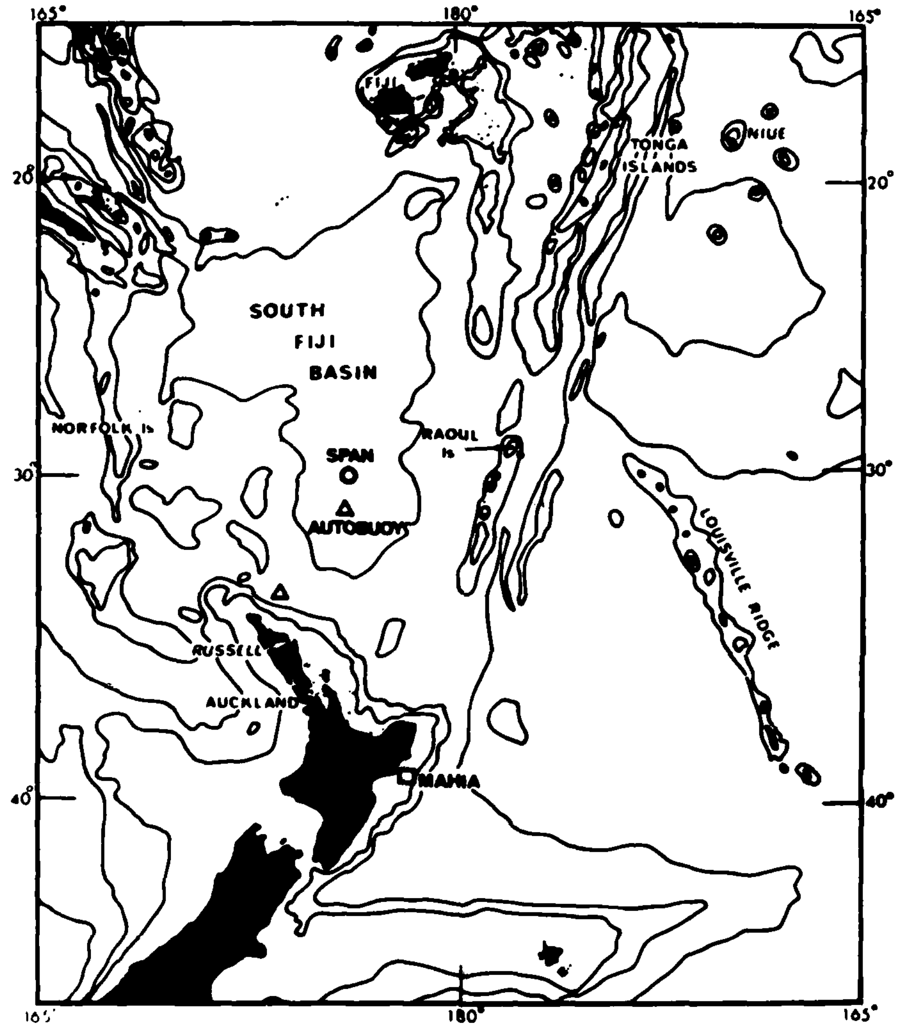
Introduction

There has been considerable conjecture concerning the possibility of a low-frequency wind-generated noise mechanism. Perrone, here at NUSC, showed a correlation between noise level and wind speed at very low frequencies, which suggests the existence of such a mechanism. Wilson's interpretation of Piggott's low-frequency data indicates two distinct wind dependency regions, the transition is at about 200 Hz. It has been hypothesized that the generation of low-frequency noise is due to turbulence rather than the bubbles and spray that produce noise at higher frequencies. Recently theoretical predictions have been put forth by the Russians Isakovich and Kur'yanov and also by Wilson.



Slide 1

The situation is excellently presented in the classic article by Wenz. Estimated average values of low frequency turbulence mechanism are followed by average values of the well-established bubbles and spray mechanism at high frequencies. Unfortunately, as you can see, the shipping noise contribution occurs right in the transition region, say typically 50 Hz, where the wind generated noise levels are relatively low — hence, the wind noise can be easily masked. Since most reported data are from high shipping density areas in the Northern Hemisphere, there has been only a limited amount of low-frequency wind-generated noise data published.



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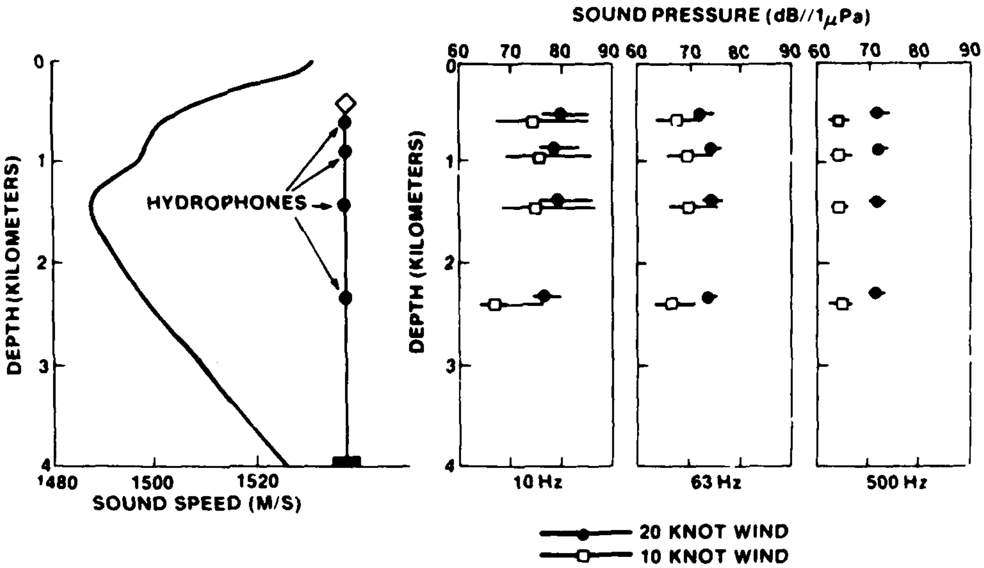
For the past several years NUSC and the New Zealand Defence Scientific Establishment have been interested in low-frequency wind-generated noise levels. The relatively low shipping density and fully developed seas in the Southern Hemisphere appear to provide an ideal measurment location, and also imply that the low-frequency wind-generated noise may be a significant factor in these large ocean areas comprised of the South Atlantic, South Pacific, and Indian Oceans. We have conducted a series of measurements in or near the South Fiji Basin, which is located to the north of New Zealand. Three principal experiments are designated by *SPAN* and *Autobuoy* located in the central basin and by *MAHIA* located down near the coast of New Zealand.

PROJECT SPAN THREE
AMBIENT NOISE DEPTH DEPENDENCE



Slide 3

Typical results are shown from Project SPAN 3, which obtained a seven day continuous recording on four hydrophones located in the deep sound channel. We have chosen three representative frequencies:

- 500 Hz — bubbles and spray noise region (shown on the right).
- 63 Hz — shipping noise region (shown in the center).
- 10 Hz — low frequency wind noise region (on the left).

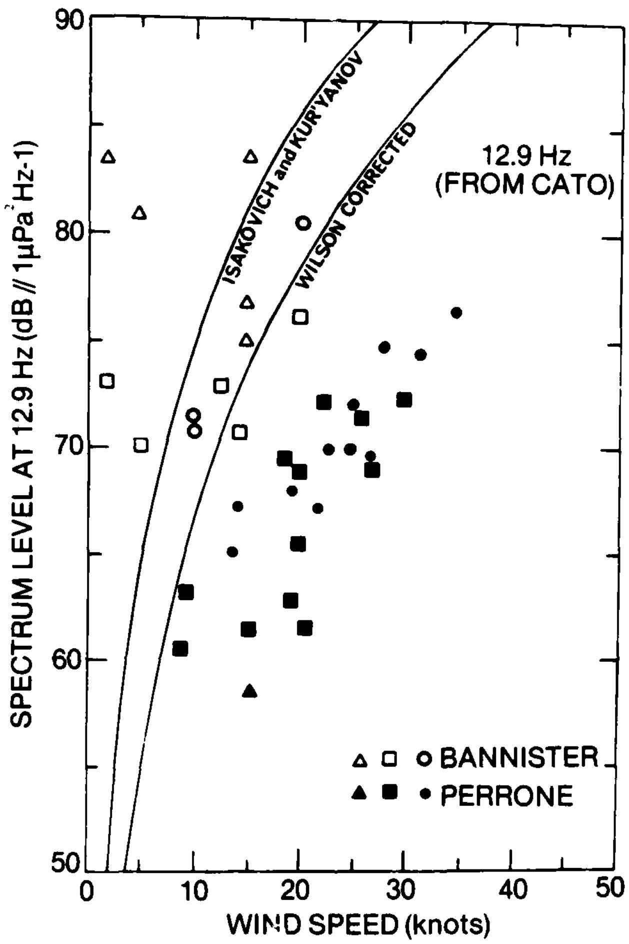
and data for two wind speeds (10 and 20 knots).

For the depths covered by these sensors, the vertical change is small, as expected from Weston's predictions.

At 500 Hz, the standard deviation is low, characteristic of wind generated noise. The wind dependency is similar to other data such as Wenz or Morris. The levels tend to be higher, however, than typical Northern Hemisphere data.

At 63 Hz, there is again a wind speed dependence. At 20 knots of wind the standard deviation is again low, but at 10 knots it is greater, suggesting a contribution due to shipping.

At 10 Hz, the levels are still wind dependent, which gives us hope for studying a low frequency mechanism. There is an increase in the standard deviation which may be at least partially due to seismic activity.



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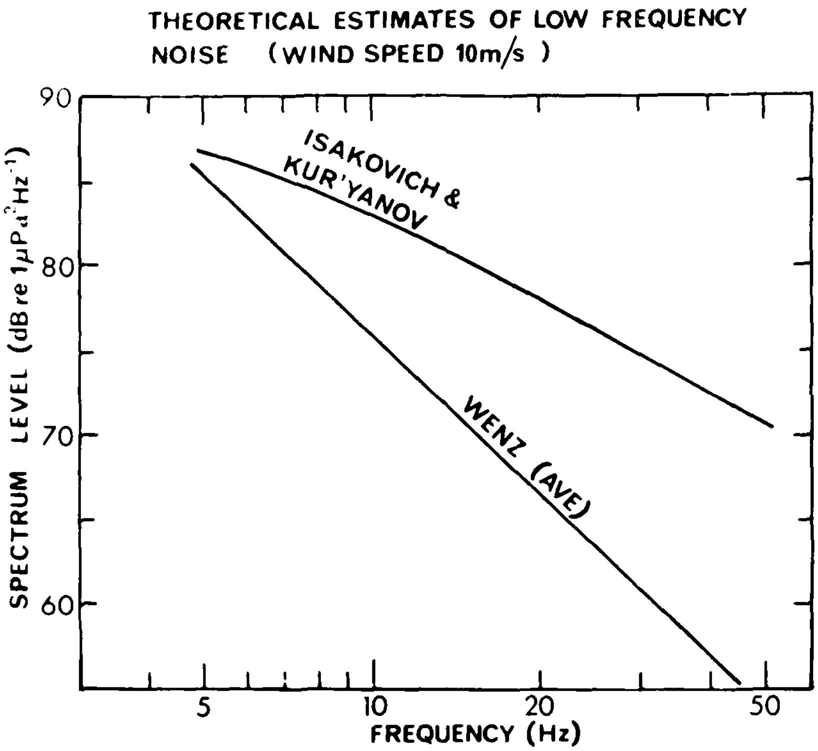
Analyzing the data, we first look at the low and high ends of the frequency range of interest (10-500 Hz), then study the middle region, which is most likely to be contaminated by shipping.

To make a direct comparison with Cato's presentation of theoretical predictions for the low frequency mechanism, we present results for 12.9 Hz. Our data (shown by the light symbols) are in reasonable agreement with either Isakovich or "corrected" Wilson, and a consistently better fit than the North Atlantic data (shown by the dark symbols). This perhaps indicates that the Southern Hemisphere sea conditions are more fully developed, but how you specify oceanographic conditions for noise generation is a topic that obviously needs further study.

We should mention that the correction of Wilson's curve is by Cato and we don't know if Wilson and Cato agree on this.



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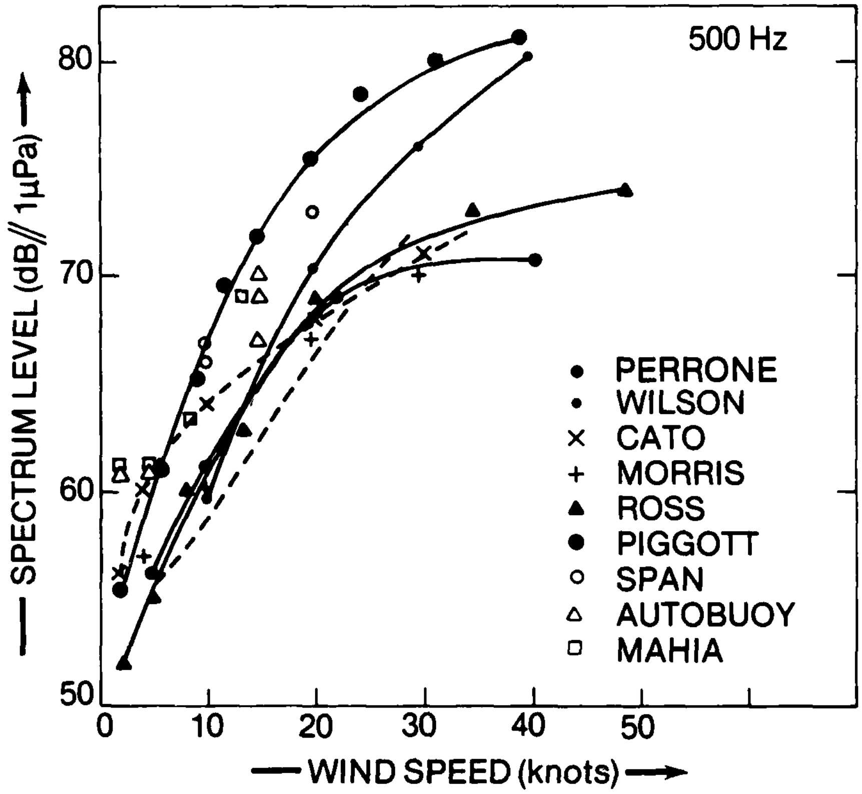
In terms of both level and slope we find the Isakovich and Kur'yanov predictions to be closest to our data. (Although the corrected Wilson has the same value at about 20 Hz, it does not have the downward slope that we observe.)

Wenz is consistently too low although the slope is reasonable.



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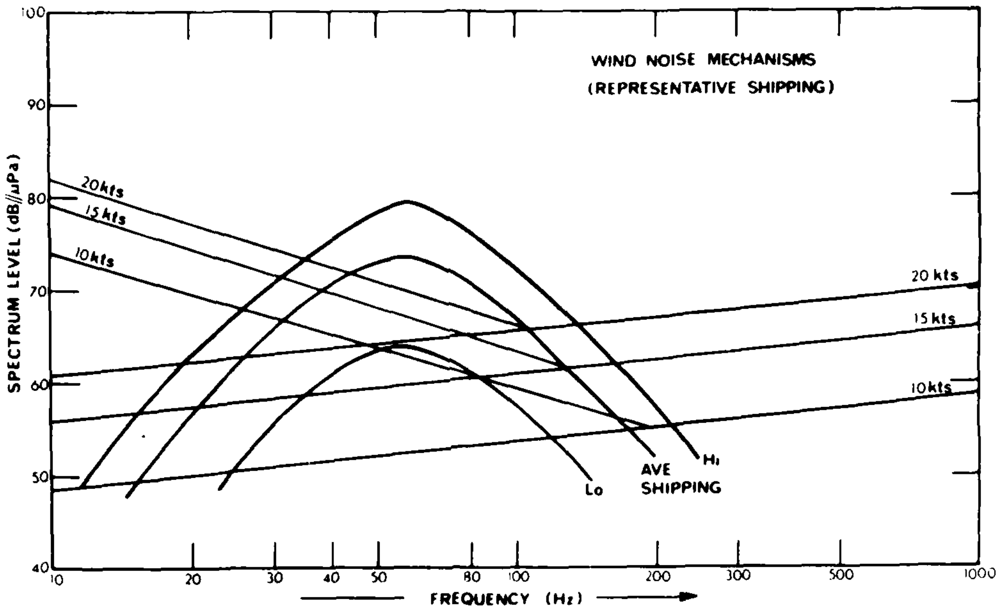
At the high frequency end (500 Hz), there are a series of wind-dependence curves from previous experiments showing variation in both slope and level. We find our data, again open symbols, at the high end regarding levels, as we were at the low frequency. Wilson, in a second paper, has proposed new curves for noise generated by bubbles and spray that are consistently higher than the Wenz curves. Their wind dependency is shown by the dark line second from the left (smallest solid dots). We find a reasonable agreement with these predictions.



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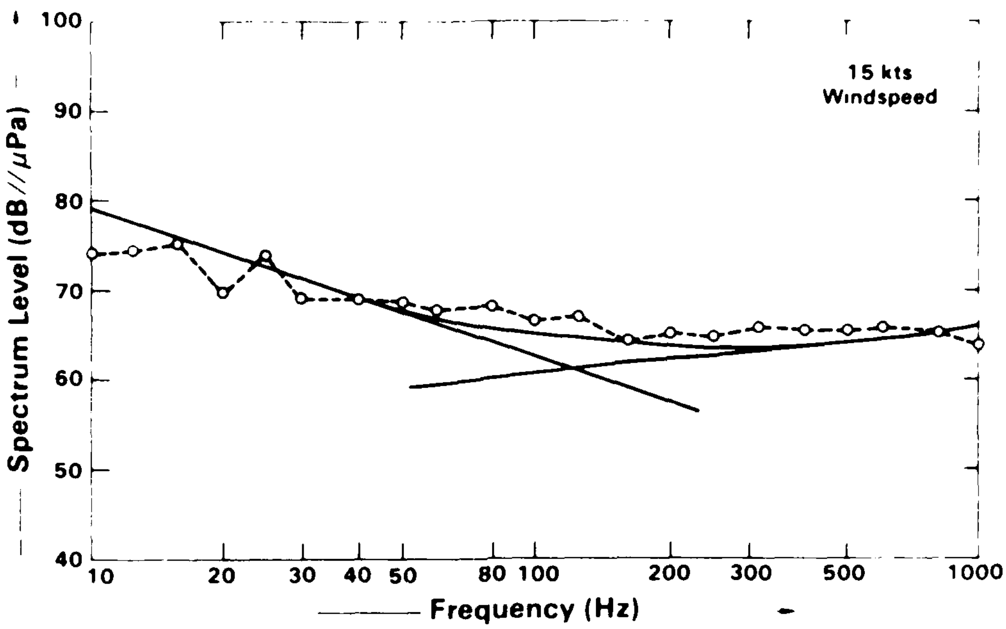
For comparison with our data, we have made the following composite curves for wind speeds of 10, 15, and 20 knots. They consist of the Isakovich and Kur'yanov curves that dominate below 100 Hz, and the Wilson bubbles and spray curves that dominate above 100 Hz.

Superimposed are three shipping noise curves. The average shipping curve was obtained from a standard shipping noise prediction program. It does fit reasonably well between the highest levels we observed (designated by the Hi curve) and the lowest levels (designated by the Lo curve).

However, any average belies the dynamic changes in level that we observe, which we believe can be explained as follows:

The *Lo curve* is apparently the Fiji Basin equivalent of the constant background shipping noise observed in the Northern Hemisphere, but at a level typically 20 dB lower. This would allow measurement of wind-generated noise at all frequencies for wind speeds above 10 knots. The *Hi curve* is the contribution of a single ship at relatively short range, which dominates when it is above the background level. In the North Atlantic, where the background is high, this may not happen very often, but here in the Southern Hemisphere the low threshold allows the effect of a single ship to dominate at longer ranges, thus, effectively extending the time of such influence. Hence, the oceans of the Southern Hemisphere have characteristic dynamic changes in the shipping frequency range. In terms of measuring low-frequency wind-generated noise, it means that we have not been able to get as much "pure" data as we had expected based on background levels alone.



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We now compare such a curve with typical data obtained by the NUSC Autobuoy at a wind speed of 15 knots. We have chosen a time when there was no significant contribution from single ships. You can see that the resultant of the two theoretical curves does not have a deep notch, as suggested by Wenz; however with a level of about 65 dB at 50 Hz, it certainly can be overwhelmed by shipping. The agreement with theory, we believe, is reasonably good, and we are using these curves for our present predictions.

We would certainly welcome an explanation as to why different oceans have different noise levels for a given wind speed. It seems to be more than just how the wind is measured; we appear to be at a point where we need a further specification of the sea conditions.

SUMMARY

1 DATA SUPPORTS TWO MECHANISMS

2 BEST FIT FROM:
ISAKOVICH and KUR'YANOV (turbulence)
WILSON (spray)

3 SHIPPING NOISE CAN BE SIGNIFICANT

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We believe that the data obtained so far support three conclusions:

1. There are significant wind-generated noise levels down to at least 10 Hz. If the frequency dependence of the bubbles and spray mechanism is correct, we do indeed require a second, low-frequency noise mechanism to explain these levels.

2. Of the published theoretical predictions available to us, we find the Isakovich and Kur'yanov results give us the best fit for a low frequency mechanism, and that the recently published Wilson curves give us the best fit in the bubbles and spray region.

3. In this remote location, wind-generated noise could be measured at all frequencies down to 10 Hz for wind speeds 10 knots and above; however, single ships could produce significantly higher levels. The result is dynamic changes in noise levels due to both wind speed changes and ship transits.

Thank you.

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